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NAVAL AIR DEVELOPMENT CENTER

WARMINSTER PA 18974

SYSTEMS DIRECTORATE

TECHNICAL MEMORANDUM 1-80 25 JANUARY 1980

FUEL CONSERVATION OPERATIONAL STUDY
VA/VF REFUELING PROCEDURES
PHASE I

NO DISTRIBUTION STATEMENT

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DEPARTMENT OF THE NAVY
NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA. 18974

Systems Directorate

TECHNICAL MEMORANDUM 1-80 25 January 1980

Fuel Conservation Operational Study
VA/VF Refueling Procedures
Phase I

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Introduction

The Navy has identified energy conservation goals for the next decade. The Naval Air Development Center (NAVAIRDEVCEN) is supporting the program with a number of technology and airborne operations studies. The focus of Phase I of this study is an investigation of hot fueling procedures and methods presently used in VF/VA ground operations. Phase II, scheduled for completion by the end of FY-80, will be a detailed examination of alternative fueling methods.

In keeping with the national policy on energy conservation, the Navy's stated goal is to reduce average fuel use by 5% per flying hour by the end of 1985, compared to base fiscal year 1975. Naval oil resources, which were set aside early in this century by President Theodore Roosevelt as an "endless" supply of crude oil for the fleet, consist mainly of Elk Hills, near Bakersfield, California, which produces 160,000 barrels per day, and Teapot Dome, Wyoming, with an output of 6,000 barrels daily. Another field, Buena Vista, which is near Bakersfield, is close to depletion. As these resources are not sufficient to meet demand, the Navy must buy from private suppliers. Recently, a jet fuel contract was awarded to the Amerada-Hess Corporation to supply 140 million gallons of jet fuel for $77.2 million. This price represents a 15.5% increase from the FY-78 price of 47.4 cents/gallon. There is no reason to believe that this rate of increase will not continue or even worsen in the future. It is clear that prudent management of energy resources is essential.

Background

Hot refueling is defined as refueling an aircraft while its engines are running. A full hot refueling procedure consists of taxiing from the runway after landing to the fueling station, refilling the fuel tanks to the desired level, and then taxiing to the parking space. It has been determined through survey of five Fighter and Attack bases that there is a high incidence of hot refueling at four of these naval air

stations. The five locations considered were: NAS Cecil Field, Florida (Figure 1); NAS Lemoore, California (Figure 2); NAS Miramar, California (Figure 3); NAS Oceana, Virginia (Figure 4); and NAS Whidbey Island, Washington (Figure 5). Aircraft are refueled from tank trucks at Whidbey Island. In order to obtain a clearer perspective on ground operations, direct observations were made during a visit to Lemoore and Miramar. The other stations were contacted by telephone and through written correspondence. Tables 1-5 summarize the data collected concerning the physical facilities and their refueling capabilities.

It is not possible to examine fuel conservation without also considering other constraints in the normal operation of a VF or VA squadron. Training requirements, deployment schedules and budgetary considerations, just to mention a few, are factors which often counteract energy saving measures.

VF/VA squadron funding is primarily determined by the degree of operational readiness. Funds are allocated as a function of Primary Mission Readiness (PMR); for example, 100% PMR would correspond to 23 flight-hours per crew per month for VF. The current funding is at the 80% PMR level. The actual funds allocated are based on the individual squadron historic cost per flight-hour. Since this amount is fixed for a given funding period, any increase in flight-hours is contingent upon an accompanying reduction in cost per flight-hour (CPH). Obviously, fuel costs are causing increases in the total CPH.

<u>Ground Operations (Foreword)</u>

Clearly, the practice of "hot refueling" does waste fuel. However, recommendation of its discontinuance would be an overly simplistic solution to a multifaceted problem. It is important to recognize that whatever conservation measures are adopted must not compromise operational readiness, safety, or effectiveness. Thus, all subsequent information is presented and must be evaluated not only in terms of fuel savings but also in accordance with its overall impact.

CECILFIELDINST 3710.1K
1 July 1977

FIELD DIAGRAM

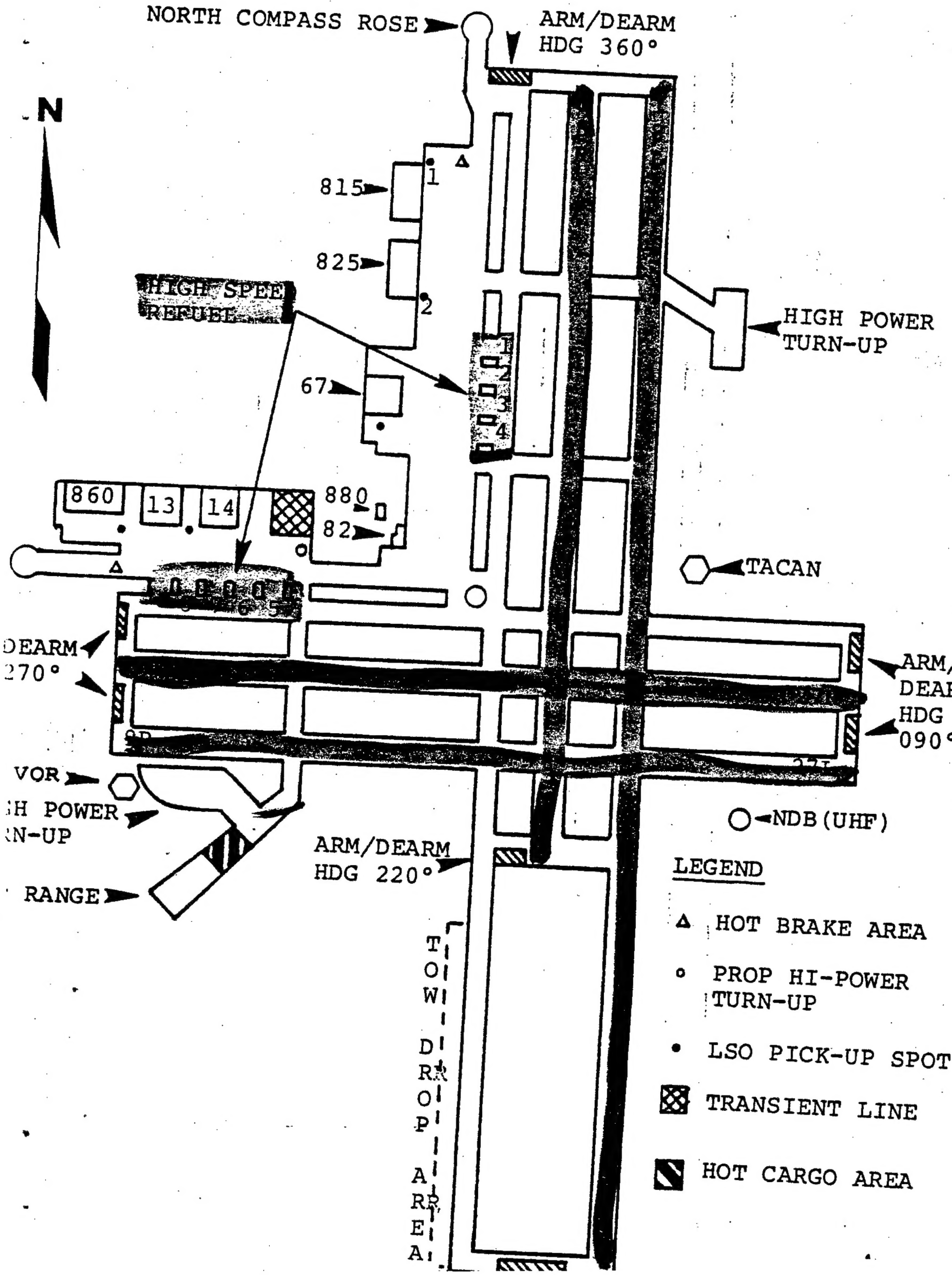


Figure 1. Airfield Diagram - NAS Cecil Field

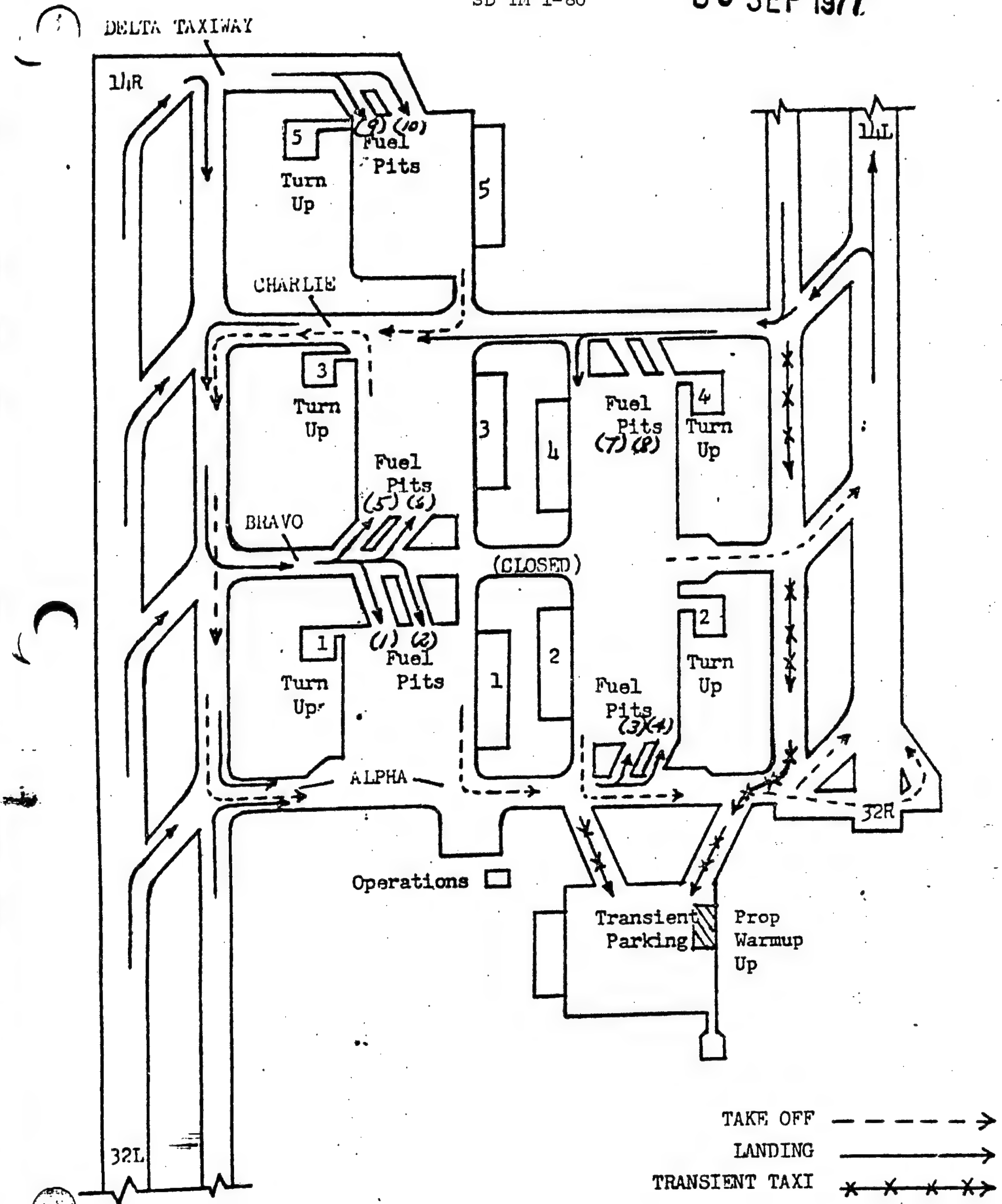
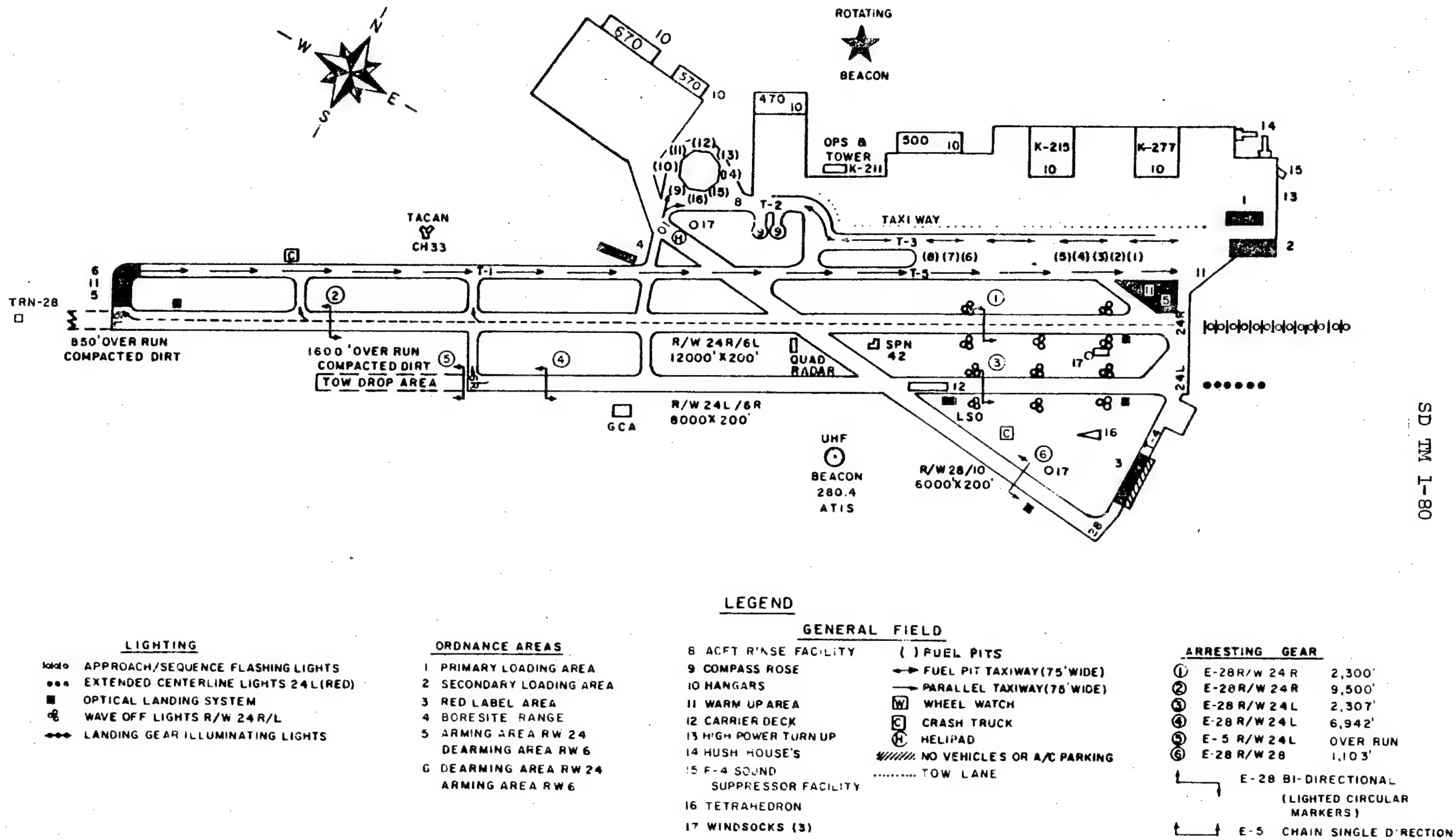


ILLUSTRATION "A"

Figure 2. Airfield Diagram - NAS Lemoore



NAS MIRAMAR FIELD DIAGRAM

Not To Scale

ILLUSTRATION I

(Revised March 1978)

Figure 3. Airfield Diagram - NAS Miramar

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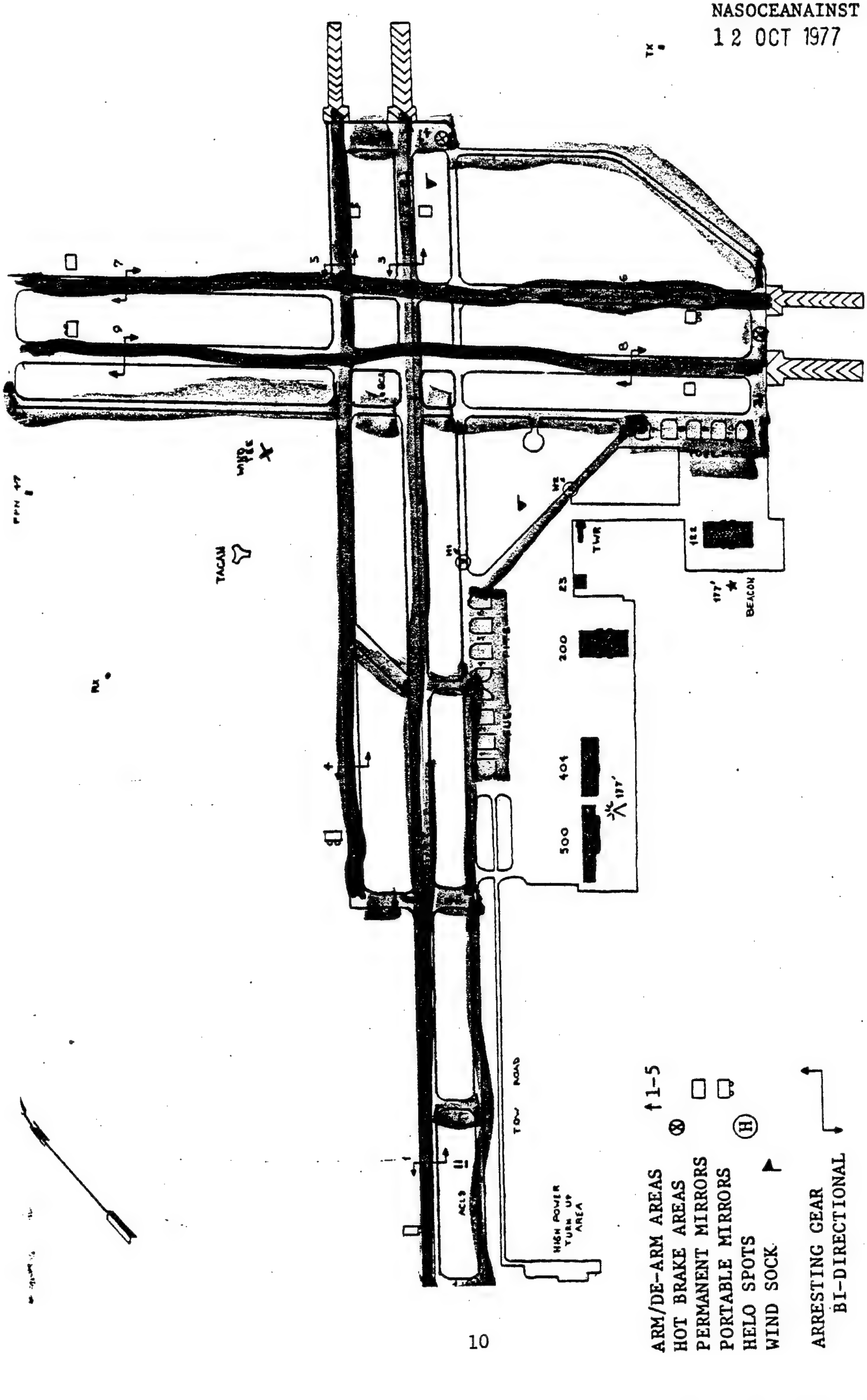

PLATE 7

Figure 4. Airfield Diagram - NAS Oceana

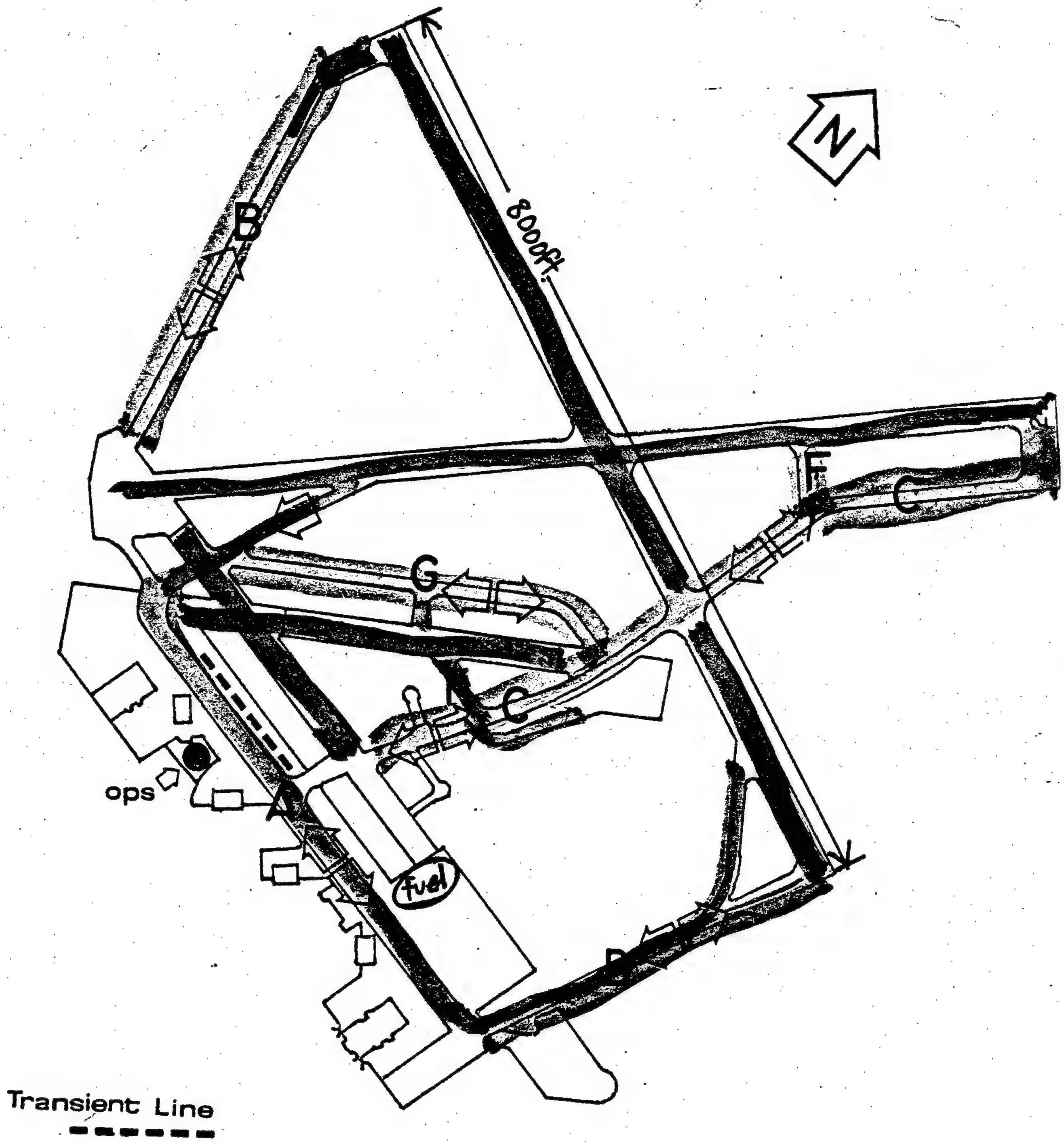

Figure 5. Airfield Diagram - NAS Whidbey Island

Ground Operations - NAS Miramar

NAS Miramar is located in San Diego, California. Currently, there are 23 squadrons on station; of these, 3 are A-4 squadrons, 5 are F-4 squadrons, and 7 are F-14 squadrons. The fueling facilities (Table 1) consist of 8 high speed refueling pits and an octagonal fueling station. As the name implies, the octagon consists of 8 high speed refuelers (Figure 2) capable of full simultaneous operation. Standard operating procedure is for A-4's to cold refuel at the fuel pits, while F-4's and F-14's are hot refueled at the "octagon" and then taxied to their parking areas (Table 3). The layout of the airfield and location of the fueling stations in relation to the hangars and runways necessitates long taxis (Table 4) once on the ground. Hangar #1, for example, is located approximately 3-1/2 miles from the octagon. Ground support at Miramar now consists of a ground support equipment (GSE) pool manned by the squadrons. This is a new program and as its resources, both from the standpoint of manpower and hardware, are limited, towing to and from the octagon has not been considered.

A-4 squadrons taxi their aircraft to the fuel pits, shut them down (cold refuel), and are then towed back to their hangars. Although it is true that the fuel pits at Miramar are more centrally located (than the octagon) in relation to most of the hangars, the main reason cold refueling can be done is that the tempo of A-4 operations is relatively slow (about 330 flights per month).

Data collected from the fuel division indicates an average of 2,250 F-4 and F-14 refueled per month. Interviews with both operational and fuel division personnel indicate that little flying is done on Mondays and Fridays, causing very intensive operations on the other weekdays.

If the alternative method of shutting down the aircraft at the octagon, transporting crew members back to their hangar, and towing

TABLE 1. FUEL FACILITY INFORMATION

	No. of Fuel Pits	Maximum No. of A/C Fueled Simultaneously	Fuel Flow Rate (GPM)	Age of Fuel Facility (yrs)
NAS Cecil Field (FL)	8	16	240	24
NAS Lemoore (CA)	10 (2 per squadron)	20	220 (can be adjusted higher)	18
NAS Miramar (CA)	8+ Octagonal Fueling Facility	16	200-300	16 Octagonal Fueling Facility - 9
NAS Oceana (VA)	10	7	80-200	20+
NAS Whidbey Island (WA)	0 (Truck refueling)	4	180-190	N/A

TABLE 2. REFUELING CAPABILITIES

	Types of Fuel Available	High Speed Refueling Available	Hot Refueling Practiced
NAS Cecil Field (FL)	115/145 JP-5	Yes	Yes
NAS Lemoore (CA)	115/145 JP-5	Yes	Yes (A-7 only)
NAS Miramar (CA)	115/145 JP-5 JP-4	Yes	Yes
NAS Oceana (VA)	115/145 JP-5	Yes	Yes
NAS Whidbey Island (WA)	115/145 JP-5	No	No (except during FCLP)

TABLE 3. FUELING INFORMATION

	Aircraft Type	Average Time to Fuel (min)	Minimum Time to Fuel (min)	Maximum Time to Fuel (min)
NAS Cecil Field (FL)	A-4 A-7	5-10 5-10	5	10
NAS Lemoore (CA)	A-4 A-7	3-5 3-5	3	8
NAS Miramar (CA)	A-7 F-4 F-14	10 20 15-18	10 15 12	15 25 20
NAS Oceana (VA)	A-6 F-4 F-14	15-20 15 15	15 7-10 15	25 25 25
NAS Whidbey Island (WA)	A-6	20	20	30

TABLE 4. TAXIING RELATED INFORMATION

	Number of Runways and Length (ft)	Maximum Distance from Runway to Fueling Area (ft)	Maximum Distance from A/C Parking to Fuel Area (ft)
NAS Cecil Field (FL)	4 8,000 (3) 12,500	8,600	1,500
NAS Lemoore (CA)	2 13,500	5,500	300
NAS Miramar (CA)	3 6,000 8,000 12,000	10,000	18,500
NAS Oceana (VA)	4 8,000 (3) 12,000	6,600	900
NAS Whidbey Island (WA)	2 8,000	8,850	1,500

aircraft back to their parking spots were to be employed, substantial increases in both manning and ground support assets would be required. In addition, this may have a deleterious effect on aircraft availability. Thus, the level of ground support needed to institute cold refueling procedures would have to be carefully tuned to the anticipated VF traffic. All ancillary services such as aircraft direction, fuel monitoring in the cockpit, and transportation of aircrew back to their hangars would have to be somehow provided at the required level.

Ground Operations - NAS Lemoore

Refueling operations are already impressively economical at Lemoore, an attack squadron base. The physical layout of runways, hangars and fueling facilities (Figure 2) was designed for maximum operational convenience, and yet allow room for expansion. Each hangar has its own fuel pits, located between the runway and the hangar. The parking spots, located just outside the hangar, are within a few hundred feet of the fueling pits. About 85% of the fueling is "hot," although the decision as to whether to hot refuel is the preference of the individual squadron commander. If the ground support equipment is available, it appears that some reduction in the practice of hot refueling could be effected here without increasing manpower. The possibility should certainly be examined closely.

The tempo of operations is slower at NAS Lemoore than at NAS Miramar, especially since the end of the Vietnam War. At the time of our visit (6 December 1979), one of the hangars was not in use. There are approximately 2,100 fueling operations per month (compared to 3,300 per month at Miramar). Also, the average fill-up for attack aircraft is about 1,200 gallons of JP-5, compared to 2,500 gallons for fighters. Lamentably, the F-4 consumes 382 gallons of fuel per hour idling (Table 5) and the F-14 half that amount, while A-4, A-6, and A-7 consume about 85 gallons per hour idling. So, potential savings, although still substantial, are

TABLE 5. VF/VA CONSUMPTION RATES (JP-5 FUEL, IDLING)

A-4	550 lbs/hr	80.9 gal/hr
A6-E	700-800 lbs/hr	103-118 gal/hr
A-7	575 lbs/hr	84.6 gal/hr
A7-E	700 lbs/hr	103 gal/hr
F-4J	2600 lbs/hr	382.4 gal/hr
F-14A	1300 lbs/hr	191.2 gal/hr

orders of magnitude less than those possible for the fuel thirsty fighter aircraft. Table 6 presents hot refueling expenditures for four Fighter and Attack Jet Bases.

Flight Related Practices

Other factors beyond squadron control contribute to unnecessary fuel consumption. For example, much fuel is wasted waiting for runway clearance. It has also been reported that multiaircraft training missions are sometimes aborted after one or more of the participants is already aloft.

Fuel dumping is seldom practiced in land-based operations, except under emergency conditions. The only restriction on fuel dumping is that it is prohibited below 6,000 ft altitude. In contrast, fuel dumping does occur during carrier operations. Restrictions in the maximum landing weight are a result of maximum allowable stress in aircraft support members, structural strength of deck and limitations in the capacity of the arresting gear. Fuel from the airborne tanker is transferred to the next tanker on station in order to assure a safe landing weight for the former. Prevailing circumstances often cause large amounts of fuel to be dumped by the last tanker on station. In all, it is not unusual for 30,000 lbs of fuel per day to be dumped from aircraft deployed on a carrier.

The tempo of West Coast carrier deployments often dictates operational periods less than one month in duration. Field carrier landing practice (FCLP) is required before the next deployment each time the carrier is at sea for at least 2 weeks. The requirement of 6 FCLP's per aircraft is very fuel costly.

TABLE 6. HOT REFUELING EXPENDITURES

NAS Lemoore

A-7 94 refuel per day x 85% of these hot refuel =

79.9 hot refuel per day

A-7 hot refuel + taxi

$$79.9 \frac{}{\text{day}} \times \frac{9 \text{ min}}{60 \text{ min/hr}} \times 84.6 \frac{\text{gal}}{\text{hr}} = 1073.6 \frac{\text{gallons}}{\text{day}}$$

monthly total NAS Lemoore = 21,472 gal/month

NAS Miramar

F-4 hot refuel + taxi

$$48 \frac{}{\text{day}} \times \frac{16 \text{ min}}{60 \text{ min/hr}} \times \frac{382.4 \text{ gal}}{\text{hr}} = 4894.7 \frac{\text{gallons}}{\text{day}}$$

F-14 hot refuel + taxi

$$64 \frac{}{\text{day}} \times \frac{16 \text{ min}}{60 \text{ min/hr}} \times 191.2 \frac{\text{gallons}}{\text{hr}} = \begin{array}{ll} \underline{3263.1} & \text{gal/day} \\ 8157.8 & \text{gal/day} \end{array}$$

monthly total NAS Miramar = 163,156 gal/month

NAS Oceana

F-4

$$72.5 \frac{}{\text{day}} \times \frac{16 \text{ min}}{60 \text{ min/hr}} \times 382.4 \frac{\text{gal}}{\text{hr}} = 7393.1 \text{ gal/day}$$

F-14

$$72.5 \frac{}{\text{day}} \times \frac{16 \text{ min}}{60 \text{ min/hr}} \times 191.2 \frac{\text{gal}}{\text{hr}} = 3696.5 \text{ gal/day}$$

A-6

$$75 \frac{}{\text{day}} \times \frac{9 \text{ min}}{60 \text{ min/hr}} \times 103 \frac{\text{gal}}{\text{hr}} = \begin{array}{ll} \underline{1158.8} & \text{gal/day} \\ 12248.4 & \text{gal/day} \end{array}$$

monthly total NAS Oceana = 244,968 gal/month

TABLE 6. HOT REFUELING EXPENDITURES (cont)

NAS Cecil Field

A-4 and A-7

135 aircraft refueling per day x 85% of these hot refuel = 114.75 hot refuel per day

$$114.75 \frac{}{\text{day}} \times \frac{9 \text{ min}}{60 \text{ min/hr}} \times 81.4 \frac{\text{gallons}}{\text{hr}} = 1140.1 \frac{\text{gallons}}{\text{day}}$$

monthly total NAS Cecil Field = 28,022 gal/month

Total	NAS Lemoore	21,427
	NAS Miramar	163,156
	NAS Oceana	244,968
	NAS Cecil Field	28,022
		457,618 gal/month

Training Areas

Every command interviewed complained about the excessive distances between their stations and the primary training areas. The Aerial Combat Maneuvering Range (ACMR) is located near Yuma, Arizona, a distance of 186 miles from NAS Miramar. Operational personnel at Miramar have stated that the ACMR is underutilized because it is so far away. In fact, only 25% of ACM is actually performed at the range; the remainder is done over the Pacific Ocean about 75 miles from station. When the ACMR at Yuma is used, the round trip transit requires approximately 1 hour. The net effect is that both training and material resources are not utilized efficiently. Transit routes to and from the ACMR are at 19,000 and 20,000 ft, respectively, which are not fuel efficient altitudes. These routes are controlled by FAA, as they cross commercial air space.

A similar situation exists at NAS Lemoore, where the principal training area is located at NAS Fallon, Nevada, a distance of 220 miles. Other areas often used by the Light Attack Wing at Lemoore are: China Lake (approximately 135 miles away) and Nellis Air Force Base, Nevada (approximately 270 miles away).

Finding alternate, more proximate training areas is a very expensive proposition. For instance, purchasing land for a training site near NAS Lemoore, which is located amid the fertile San Joaquin Valley farmlands, would be very expensive. In fact, unused tracts of land within the boundaries of the station (10 miles square) are leased for farming.

Conclusions

Using the hot refueling expenditure data from Table 6, we can project a yearly figure of over 5 million gallons of JP-5 expended during hot refueling. Against this must be balanced the cost of additional ground support equipment and personnel for transporting pilots and aircraft back to the hangars, with a cold refueling procedure. There are certain circumstances under which cold refueling would not be expedient. FCLP, carrier qualification flights (CARQUAL), and other training missions require hot refueling and hot seating, in order to make maximum use of available aircraft and manpower.

The remoteness of training areas is fuel costly, but the cost of acquiring geographically desirable locations would obviously only be repaid after many years.

Tailoring fuel loads to the particular mission is done more often in the attack community than in the fighter community. It has been the practice of fighter squadrons to top off fuel tanks to avoid condensation, which hinders good engine performance.

Recommendations

Phase I recommendation:

- o Where circumstances allow, fuel loads should be tailored to the planned training mission

The following efforts are recommended for Phase II:

- o Analyze cost effectiveness of cold refueling operating procedures with special emphasis on Master Fighter bases

- o Investigate cold refuel during non-peak fueling periods using existing ground support equipment

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